Amendments to the Drawings

The replacement sheets of drawings attached hereto as **Exhibit A** include changes to, and replace, Figures 15A, 16 and 30 of the original sheets of drawings. Figures 15A, 16 and 30 are now labeled as prior art.

The label for the ordinate in the graph shown in Fig. 15A has been changed to "Z".

The label for step S4 in Fig. 16 has been corrected to "DETERMINE PHASE RANGE OF EACH PROJECTION DATA USED FOR EACH VOXEL".

The label for the "START" block in Fig. 30 has been corrected.

Attachment: replacement sheets of drawings for Figures 15A, 16 and 30.

REMARKS

The application has been reviewed in light of the Office Action dated July 5, 2007. Claims 1-14 are pending. By this Amendment, claims 1-4, 7 and 9-14 have been amended to place the claims in better form for examination and to clarify the claimed subject matter. Accordingly, claims 1-14 are presented for reconsideration, with claims 1 and 10 being in independent form.

The drawings were objected to as purportedly having informalities. The specification was objected to as purportedly having informalities.

The replacement sheets of drawings attached hereto as **Exhibit A** include changes to, and replace, Figures 15A, 16 and 30 of the original sheets of drawings.

The specification has been reviewed and amended to correct the formal matters noted in the Office Action.

Withdrawal of the objection to the drawings and the objection to the specification is respectfully requested.

Claims 5-9 and 12 were objected to as having informalities. Claims 7-9 were objected to under 37 CFR 1.75(c), as purportedly in improper form. Claims 5-9 and 12-14 were rejected under 35 U.S.C. §112, second paragraph, as allegedly indefinite.

In response, the claims have been carefully reviewed and amended with particular attention to the points raised in the Office Action.

Regarding the term "polygonal display pixel", the Examiner is referred to, for example, paragraph [0129] of the application wherein it is pointed out that a display pixel need not be rectangular, but can be hexagonal, and the number of projection phases correspond to the number of sides in the polygonal display pixel.

Withdrawal of the objections to the claims and the rejection under 35 U.S.C. §112, second paragraph, is respectfully requested.

Claims 1-3 were rejected under 35 U.S.C. § 103(a) as purportedly unpatentable over Noo et al. in view of Noo et al., "Single-slice rebinning method for helical cone-beam CT", U.S. Patent No. 6,947,584 to Avila et al. and further in view of U.S. Patent No. 6,097,784 to Tuy. Claims 1, 4 and 5 were rejected under 35 U.S.C. § 103(a) as purportedly unpatentable over US 2003/0073893 A1 (Hsieh '893) to in view of Avila et al. Claim 6 was rejected under 35 U.S.C. § 103(a) as purportedly unpatentable over Hsieh '893 in view of Avila et al and further in view of U.S. Patent No. 6,490,333 (Hsieh '333). Claims 10-12 and 14 were rejected under 35 U.S.C. § 103(a) as purportedly unpatentable over U.S. Patent No. 5,796,803 to Flohr et al. in view of U.S. Patent No. 5,889,833 to Silver, Bruder et al., "Single-Slice Rebinning Reconstruction in Spiral Cone-Beam Computed Tomography", and Tuy. Claim 13 was rejected under 35 U.S.C. § 103(a) as purportedly unpatentable over Flohr in view of Silver, Bruder and Tuy and further in view of Noo.

This application relates to a tomograph which generates a tomographic image of an examinee using projection data obtained through a radiation detector from a radiation source moving in the body axis direction relative to the examinee. Conventional three-dimensional back projection approaches have attendant problems/deficiencies, such as poor data utilization rate, artifacts from data discontinuity, etc.

The present application is directed to various improvements devised by applicant for an X-ray tomograph.

In one aspect, a reconfiguration means for creating a three-dimensional tomographic image in a region in concern of the examinee from the detected projection data, determines, for

each voxel, a projection data phase range as an optional angle of 180 degrees or more, superimposes a reconfiguration filter, assigns weights to data of the same phase or opposite phase for each phase for this projection data phase range and three-dimension back projects this filter-processed projection data over said projection data phase range determined for each voxel along the irradiation trace of the radiation beam. Independent claim 1 addresses these features, as well as additional features.

In another aspect, a reconfiguration means for creating a three-dimensional tomographic image in a region in concern of the examinee from the detected projection data, determines, for each voxel, a projection data phase range as an optional angle of 180 degrees or more, and calculates an approximate straight line for a curve obtained by projecting a spiral trace of an X-ray source with respect to said examinee onto a plane parallel to said go-around axis. Independent claim 10 addresses these features, as well as additional features.

Such features of the claimed subject matter enable generation of distortion attributed to data discontinuity to be suppressed, and a tomographic image of high image quality, not eliminating data redundancy but rather using it in three-dimensional back projection calculation, to be obtained (see application, for example, at page 5, line 24 through page 6, line 5). Further, arcsin calculation on a fan-parallel beam conversion and back projection processing according to a set FOV range in three-dimensional back projection calculation is simplified and the processing speed of the tomography is significantly increased without degrading image quality (see application, for example, at page 6, lines 6-12).

Noo, as understood by applicant, proposes an approach for reconstructing a tomographic image utilizing 2D multislice fan beam filtered backprojection, wherein an examinee on a bed is placed between an X-ray source and a radiation detector, the X-ray source and the radiation

detector are rotated around the examinee, the bed can be moved with respect to a go-around axis while the X-ray source and the radiation detector are rotated, radiations passed through the examinee are detected by the radiation detector and a tomographic image of an area of concern of the examinee is reconstructed on the basis of the projection data detected. In the approach proposed by Noo, projection data range is determined for each slice plane, reconstruction filter is superimposed, weights are assigned to the projection data and then such data is back projected.

However, Noo does not disclose or suggest determining, for each voxel, a projection data phase range as an optional angle of 180 degrees or more and creating a three-dimensional image.

Avila, as understood by applicant, proposes a volume imaging system which progressively constructs, analyzes, and updates three dimensional models while acquiring cross-sectional data. The system constructs and displays three-dimensional renderings, and performs quantitative calculations in real time during the imaging system data collection process.

Tuy, as understood by applicant, proposes an approach for image reconstruction from partial cone beam data which includes collecting the partial cone beam data in two-dimensional arrays. The collected data corresponds to rays of radiation diverging in two dimensions from a common vertex as the vertex travels along a curve. Each element of the data represents a line integral of an object being reconstructed taken along each ray. The data is then pre-weighted and a local coordinate system is defined. Prior to three-dimensional back projection, weights are assigned to projection data. A one-dimensional convolution of the pre-weighted data is computed in the local coordinate system along a direction which is tangential to the curve along which the vertex travels. The convolved data is weighted and three-dimensionally backprojected.

However, Avila and Tuy, like Noo, does not disclose or suggest determining, for each voxel, a projection data phase range as an optional angle of 180 degrees or more.

Likewise, the other cited references are of no avail.

Hsieh '893, as understood by applicant, proposes a CT imaging system that includes a source of a conical beam of radiation and a two-dimensional detector array arranged on opposite sides of an axis of rotation. Projection data is acquired in a conventional manner as the source and detector array make a full rotation about an object. A conventional half-scan image reconstruction algorithm is applied to the projection data at a plurality of different center-view angles to produce a plurality of sub-images. The regions of each sub-image are defined by a weighting function, and the sub-images are combined to form a cross-sectional image of the object.

Hsieh '333, as understood by applicant, proposes an approach for reconstructing a CT image of an object including initializing a CT imaging system in a step-and-shoot mode, performing an axial scan to generate a plurality of projection samples, rebinning the projection samples to a set of tilted parallel geometry samples, and reconstructing an image of the object using the rebinned projection samples.

However, the above-mentioned cited references do not disclose or teach determining, for each voxel, a projection data phase range as an optional angle of 180 degrees or more, as provided by the subject matter of claim 1 of the present application.

Likewise, none of the above-mentioned cited references disclose or teach reconfiguration means that determines, for each voxel, a projection data phase range as an optional angle of 180 degrees or more, and calculates an approximate straight line for a curve obtained by projecting a spiral trace of an x-ray source with respect to said examinee onto a plane parallel to said go-around axis, as provided by the subject matter of claim 10 of the present application.

Flohr, as understood by applicant, proposes an approach for approximative image

reconstruction in a CT apparatus with a multi-row detector in spiral operation, wherein a reinterpolation from fan data to parallel data (rebinning) is first carried out independently for all rows of the detector, and with the parallel data, an image is reconstructed by having each beam contribute to the image with a weight that depends on the respective distance of the beam to the image plane. Thus, in the approach proposed by Flohr, in order to enable image reconstruction with high speed, fan beam projection data are re-arranged to parallel beam projection data, weights are assigned on the basis of a distance between the parallel beam projection data and reconstruction plane, and an image is reconstructed.

Silver, as understood by applicant, proposes an approach for performing backprojection wherein each pixel is provided with a back projection range of itself, and an image is reconstructed using the given back projection range.

However, in Silver, the back projection range is limited to 180 degrees (minimal data) or 360 degrees (full data). In such an approach, that is, the back projection range is limited to 180 degrees or 360 degrees, data redundancy is not different for each voxel. That is, in the approach proposed by Silver, it is not necessary to assign weights to data of the same phase or opposite phase for each phase (claim 1 of the present application).

Accordingly, the approach proposed by Silver cannot obtain the advantages of suppressing generation of distortion attributed to data discontinuity, and obtaining a tomographic image of high image quality not by eliminating data redundancy but rather using it in three-dimensional back projection calculation, as provided by the subject matter of claim 10 of the present application.

Bruder, as understood by applicant, proposes an approach for performing Cone-Beam CT utilizing single slice rebinning reconstruction. In the approach, a reconstruction plane along with

an "optimum" tilt angle v are determined.

However, none of Flohr, Silver and Bruder discloses or suggests that a projection data phase range corresponding to each voxel is determined as an optional angle of 180 degrees or more, and an approximate straight line is calculated for a curve obtained by projecting a spiral trace of an X-ray source with respect to the examinee onto a plane parallel to the go-around axis.

Applicant simply does not find teaching or suggestion in the cited art, however, of an X-ray tomograph including reconfiguration means for creating a three-dimensional tomographic image in a region in concern of the examinee from the detected projection data, wherein the reconfiguration means determines, for each voxel, a projection data phase range as an optional angle of 180 degrees or more, superimposes a reconfiguration filter, assigns weights to data of the same phase or opposite phase for each phase for this projection data phase range and three-dimension back projects this filter-processed projection data over said projection data phase range determined for each voxel along the irradiation trace of the radiation beam, as provided by the subject matter of claim 1 of the present application.

Likewise, Applicant does not find teaching or suggestion in the cited art of an X-ray tomograph including a reconfiguration means for creating a three-dimensional tomographic image in a region in concern of the examinee from the detected projection data, determines, for each voxel, a projection data phase range as an optional angle of 180 degrees or more, and calculates an approximate straight line for a curve obtained by projecting a spiral trace of an X-ray source with respect to said examinee onto a plane parallel to said go-around axis, as provided by the subject matter of claim 1 of the present application.

Accordingly, for at least the above-stated reasons, Applicant respectfully submits that independent claims 1 and 10, and the claims depending therefrom, are patentable over the cited

art.

In view of the amendments to the claims and remarks hereinabove, Applicant submits that the application is now in condition for allowance. Accordingly, Applicant earnestly solicits the allowance of the application.

If a petition for an extension of time is required to make this response timely, this paper should be considered to be such a petition. The Patent Office is hereby authorized to charge any fees that are required in connection with this amendment and to credit any overpayment to our Deposit Account No. 03-3125.

If a telephone interview could advance the prosecution of this application, the Examiner is respectfully requested to call the undersigned attorney.

Respectfully submitted,

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EXHIBIT A

to
AMENDMENT
(Serial No. 10/524,341)